Open Access
J. Food Proc. & Nutr. Res., 2024, 1(2):75-85
ISSN (Online): 3078-9133; ISSN (Print):3078-9125
DOI: https://doi.org/10.22194/ JFPNR /24.1009
https://societyfia.org/journal/JFPNR

Peppermint Oil Nanoemulsion As Natural Preservative and Antioxidant in Mango Juice

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Mango (*Mangifera indica* L.) is the world's most important tropical fruit. In the tropical regions of South Asia, it is also known as the King of Fruits. Utilization of essential oils (EOs) regarded as an expanding alternative technology in the preservation of fruit juices. Previous studies have demonstrated the effective utilization of essential oils possessing inherent antimicrobial properties in the preservation of fruit juices, thereby controlling the growth of microorganisms responsible for food spoilage. The current research plan aims to evaluate preservative and antioxidant potential of peppermint oil nanoemulsion. For the purpose physiochemical properties such as pH, titratable acidity, total soluble solid, turbidity was determined. The nutritional composition such as vitamin C and mangiferin were determined. Phenolic compounds in mango juice were quantified using spectrophotometric analysis. TPC (total plate count) was also used to determine the concentration of bacteria and fungi (yeast and mold) as well as sensory evaluation was conducted by a trained panel. The results indicated that a nanoemulsion with diameter (<200 nm) was developed utilizing the extract derived from peppermint plants. Physicochemical result of this study revealed that increase in TSS was observed in all samples except T5. Maximum increased in TSS was observed in T2 (12±0.1-13±0.5 °Brix) and T3 (12±0.1-12±0.8 °Brix). Maximum decrease in ascorbic acid was observed in T5 (2.257±0.005-0.865±0.003). Similarly, maximum decrease was observed in T5 (1.372±0.004-0.776±0.003). The sensory analysis revealed the sensory qualities of mango juice. It was concluded from the results that peppermint oil nanoemulsion proved to be a good natural preservative and antioxidant.

Keywords: Peppermint oil nanoemulsion, antioxidant, natural preservative, mango juice, essential oils.

INTRODUCTION

Mango (*Mangifera indica* L.) is an important fruit which is grown in tropical and subtropical region of Indo-Pak. Botanically, mango is an exotic fruit belongs to Anacardiaceae (Wang *et al.,* 2020). These regions are producing mango up to about 43 million tons. Pakistan is 5th biggest mango producing countries in the World and covers 4.3% of the Global mango production (Musharaf *et al.,* 2016; Tang *et al.,* 2021). The consumption of fruit juice has surged globally, reaching 45.4 billion liters in 2018, with a projected growth to 50.6 billion liters by 2024 (Rai *et al.,* 2022). The inclusion of fruits such as mango in one's diet could effectively address vitamin A deficiency. Additionally, dietary carotenoids have been recognized for their potential in mitigating the risk of specific cancers and eye-related ailments (Krinsky and Johnson, 2005). The mango, scientifically known as *Mangifera indica* L., is considered to be one of the earliest and most significant of all tropical fruits. It is widely cultivated in nearly all tropical and sub-tropical nations. Pakistan is a significant producer of mangoes, generating substantial quantities of this fruit. Pakistan cultivates a diverse range of mango varieties, including Chonsa, Saroli, Anwar Ratual, Fajri, Dusehri, Sindheri, Katha, Langra, Totapari, Malda, Desi, Almas, and Ting, among others. Pakistan is a significant producer of mangoes, generating substantial quantities of this fruit. The consumption of mango primarily occurs in the form of fresh fruit; however, its perishable characteristics limit its ability to be stored for extended periods. To ensure the availability of

Majeed, H., M. Ayaz, U. Majeed, M.I. Babu, K.J. Iqbal and M. Anjum. 2024. Peppermint Oil Nanoemulsion as Natural Preservative and Antioxidant in Mango Juice. Journal of Food Processing and Nutrition Research 1:75-85.
[Received 13 Sep 2024; Accepted 10 Nov 2024; Published 2 Dec 2024]
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mango fruit throughout the year, various processing methods are employed, such as the production of juices, squashes, pickles, chutney, jams, nectars, toffees, and canned mango slices (Hussain *et al.,* 2003).

The degradation of fruit juices during extraction can occur as a result of physical factors, enzymatic activity inherent to the fruit, microbial spoilage, or a combination of these factors. Fruit fluids are rich in both acid and sugar content. The presence of a significant amount of sugar in a food product increases the likelihood of contamination by pathogens that affect humans, such as fungi and bacteria that are associated with foodborne illnesses. Additionally, the high sugar content also creates favorable conditions for the growth of microorganisms that cause food spoilage. Several studies have reported the presence of pathogenic bacteria that exhibit the ability to survive in highly acidic environments characterized by a low pH (Castillo *et al.,* 2006).

Fruit juice has been linked to a number of foodborne outbreaks. Foodborne illnesses resulting from the presence of pathogenic bacteria continue to pose a significant challenge to both food safety and public health. In recent years, there has been a notable rise in consumer consciousness regarding the potential health hazards associated with synthetic preservatives. Consequently, this has led to a rise in the utilization of plant-based antioxidant and antimicrobial substances as alternative preservatives, owing to their natural properties. Essential oils (EOs) have been acknowledged as a category of natural preservatives with documented antimicrobial and antioxidant properties, as evidenced in the existing literature (Noori *et al.,* 2018; Moosavy *et al.,* 2017). Essential oils are a mixture of bioactive molecules with several fascinating biological activities, such as antibacterial, antifungal, and antibiofilm properties permitting them to be used in a variety of fields, including food, cosmetics, medicine, and pharmacy. In recent times, nanoemulsions have attracted significant interest owing to their distinct advantages in comparison to conventional emulsions. Nanoemulsion refers to a colloidal system characterized by the presence of monodisperse particles that exhibit kinetic stability (Li *et al.,* 2018). The oil-in-water nanoemulsion is composed of oil droplets with diameters ranging from 10 to 100 nm, which are dispersed in an aqueous solution that appears transparent or slightly turbid (McClements, 2011; Prakash *et al.,* 2018; Balasubramani *et al.,* 2017). Nanoemulsions are usually synthesized using surfactants or co-surfactants to stabilize oil droplets in an aqueous phase. This process is facilitated by specialized instruments such as sonicators, micro-fluidizers, high-pressure homogenizers, and high-shear homogenizers (Ozogul *et al.,* 2020; Donsì and Ferrari, 2016; Balasubramani *et al.,* 2017).

Peppermint produces 0.1–1% volatile oil, which is predominantly composed of menthone (20–31%), menthol (29–48%), menthyl acetate (3–10%), and menthofuran (6.8%). Additional pharmacologically active constituents include Bitter substances, polymerized polyphenols (19%), flavonoids (12%), carotenoids, caffeic acid, choline, tocopherols, betaine, and tannins (Karuza *et al.,* 1996; Shimada *et al.,* 1992; Sokovic *et al.,* 2009). Peppermint oil (PO) is soluble in 70% ethanol and insoluble in water. One of the most widely used EOs, it has antibacterial, antifungal, and antiviral properties and is used in food, cosmetics, and pharmaceutical products. PO's antibacterial characteristics are mostly attributable to the cumulative effects of chemicals such as menthol, methyl acetate, menthone, and limonene (Scavroni *et al.,* 2005). It is hypothesized that peppermint oil nanoemulsion will effectively inhibit microbial growth and maintain the quality of mango juice during storage.

MATERIALS AND METHODS

Mango Pulp, Citric acid, sodium benzoate, sodium citrate, CMC, sugar, sunset yellow color, Tartrazine color, Mango flavor (7007), Mango flavor (3000) were purchased from the local market. Peppermint oil nanoemulsion, potassium metabisulphite and potassium sorbate were provided by research lab store. The investigation was conducted using the tools and equipment's from the laboratory.

***Preparation of mango pulp*:** Mangoes were purchased from the market and then washed properly with tap water. Sorting on the base of good quality, size and properly ripped mangoes. Peeling and crushing of mangoes done by knife. The crushed mangoes were blended properly with juicer blender for 5 minutes.

***Pasteurization of mango pulp*:** Pulp was then pasteurized in a stainless-steel container at 85±2 °C for 1 minute to reduce the microbial load. Filled it in plastic bottle and stored in refrigerator at 4 ºC.

***Preparation of mango juice by Hurdle technology*:** In table no. 1, will show the preparation of mango juice with different concentration of preservatives and peppermint oil nanoemulsion. Sample was prepared from 0 % mango pulp, citric acid (1.8 g), sodium benzoate (0.15g), sodium citrate (0.15g), CMC (0.6 g), sugar (118.5 g), sunset yellow color (0.018 g), tartrazine color (0.006 g), mango flavor 7007(0.2ml), mango flavor 3000 (0.2 ml), water (01liter). Sample T1 was prepared from 10% mango pulp + sodium benzoate (0.15g), sodium citrate (0.15g), CMC (0.6 g), sugar (118.5 g), sunset yellow color (0.018 g), tartrazine color (0.006 g), mango flavor 7007(0.2ml), mango flavor 3000 (0.2ml), Water (01liter). Sample T2 was prepared from 10% mango pulp + sodium benzoate (0.10g) + peppermint oil nanoemulsion (0.5) ml, Sodium citrate (0.15g), CMC (0.6 g), sugar (118.5 g), sunset yellow color (0.018 g), tartrazine color (0.006 g), mango flavor 7007(0.2ml), mango flavor 3000 (0.2ml), water (01 liter). T3 was prepared from 10% mango pulp + sodium benzoate (0.10g) + potassium metabisulphite (0.10g) + peppermint oil nanoemulsion (0.5ml), sodium citrate (0.15g), CMC (0.6 g), sugar (118.5 g), sunset yellow

color (0.018 g), tartrazine color (0.006 g), mango flavor 7007(0.2ml), mango flavor 3000 (0.2ml), water (01liter). T4 was prepared from 10% mango pulp + sodium benzoate (0.10g) + potassium metabisulphite (0.10g), peppermint oil nanoemulsion (0.10ml), potassium sorbate (0.10g), sodium citrate (0.15g), CMC (0.6 g), sugar (118.5 g), sunset yellow color (0.018 g), tartrazine color (0.006 g), mango flavor 7007(0.2ml), mango flavor 3000 (0.2ml), water (01 liter). T5 was prepared from 10% mango pulp + potassium metabisulphite (0.10g) + potassium sorbate (0.10g) + peppermint oil nanoemulsion (0.10ml), sodium citrate (0.15g), CMC (0.6 g), sugar (118.5 g), sunset yellow color (0.018 g), tartrazine color (0.006 g), mango flavor 7007(0.2ml), mango flavor 3000 (0.2ml), water (01 liter). The recipe of mango juice was blended in the juicer blender for 5 minutes, then homogenized in homogenizer for 2 minutes. After this juice was pasteurized at 85 ±2℃ for 1 minute and cooled at room temperature. Flavors and peppermint oil nanoemulsion were added in the juice with micro pipette. Pasteurized juices were packed in sterilized PET bottles with sterilized lids. After that, all of the samples were store for 15 days at room temperature.

Table 1. Treatments of mango juice by Hurdle technology.

Treat.	Combinations
T0	0% Mango pulp +Sodium benzoate-0.15g
T1	10% Mango pulp +Sodium benzoate 0.15g
T2	10% Mango pulp +Sodium benzoate-0.10g+ peppermint oil namoemulsion-0.5ml
T3	10% Mango pulp+ Sodium benzoate-0.10g+ potassium metabisulphite- 0.10g+peppermint oil nanoemulsion-0.5ml
T4	10% Mango pulp +Sodium benzoate-0.10g+potassium metabisulphite-0.10g+peppermint oil nanoemulsion-0.10ml+potassium sorbate-0.10g
T5	10% Mango pulp +potassium metabisulphite-0.10g+potassium sorbate- 0.10g+peppermint oil nanoemulsion-0.10ml.

***Physicochemical analysis*:** This study inspected the impact of nanoemulsion with different peppermint oil nanoemulsion on the shelf-life and quality of Mango juice during storage. The juice quality parameters were analyzed by measuring the pH, Total Soluble solids (TSS), Ascorbic acid content, turbidity and Mangiferin. The juice was stored at room temperature and 4^{o}C temperatures.

***Determination of pH*:** The mango juice was put into the beaker. Cleaned and calibrated the pH meter. Measured the pH of juice by using pH meter (MonjazebMarvdashti *et al.*, 2020).

***Determination of total soluble solids (TSS)*:** The total soluble solids content of Mango juice was assessed by using a hand refractometer. Juice was put by the dropper on the refractometer to measure the TSS of Mango juice.

***Determination of acidity*:** Acidity of mango juice was determined by titration method with 0.1N solution of NaOH. Take the sample juice 10ml with pipette and put it into the beaker. Then put two to three drops of phenolphthalein indicator in it and titrate. Titration stopped when the color of juice turned into pink color and note the reading of NaOH used during titration. Now multiply the volume used with 10ml of juice and coefficient factor 0.0064. In this way value of acidity obtains

Acidity = 10ml * 2.9ml * 0.0064

Acidity = 0.18

Juice = 10ml, NaOH used = 2.9ml, Coefficient factor = 0.0064

***Determination of phenolic content in mango juice*:** The method was described previously to utilize with some modification to measure the Mangiferin content in mango juice. Juice was taken from the bottle during storage and centrifuged at 14,000 rpm for 3 minutes. Then 3ml of juice extract putted in the cuvette with the help of dropper and placed in the UV-visible spectrophotometer to measure the mangiferin content at absorbance 257 nm. Mangiferin is a flavonoid found in mango juice. It has antioxidant properties to prevent diseases (Rasyid *et al.*, 2021).

***Determination of turbidity in mango juice*:** The method was described previously to utilize with some modification to measure the turbidity in mango juice. Juice was taken from the bottle during storage and centrifuged at 14,000 rpm for 3 minutes. Then 3ml of juice extract putted in the cuvette with the help of dropper and placed in the UV-visible spectrophotometer to measure the turbidity at absorbance 660 nm.

***Sensory evaluation*:** Sensory evaluation for taste, flavor, color, sweetness, thickness, mouthfeel and overall acceptability was done by a panels of 20 judges. The score by the panelists was given according to 9-point hedonic scale where (9 = extremely like; 8 = very much like; 7= moderately like; 6 = slightly like; 5 = neither like nor dislike; 4 = slightly dislike; 3 = moderately dislike; 2 = very much dislike and 1 = extremely dislike) was used to rate the samples. Sensory analysis was performed at the beginning day (day 0), then after 15 days during storage

***Statistical analysis*:** The findings of all the experiments were obtained by statistical analysis. The descriptive statistics viz. mean ± SE (standard error) was analyzed statistically.

RESULTS

Physicochemical analysis

***TSS (Total Soluble Solid)*:** This study examined the impact of various treatments on TSS of mango juice stored at room temperature and 4 ℃ as shown in table 2 Initial TSS of mango juice of various treatments were recorded as (12±0.1 ℃Brix).

Result of this study reveals that increase in TSS was observed in all samples except T5. Maximum increased in TSS was observed in T2 (12±0.1-13±0.5 °Brix) and T3 (12±0.1-12±0.8 °Brix). Minor decreased was observed in T5 (12±0.1-11.81±0.1 °Brix) at the end of storage for 15 days at room temperature and 4 °C respectively.

Table 2. Effect of Storage on TSS (°Brix) of mango juice at room temperature and 4℃.

Groups	TSS (°Brix)		
	0 Day	07 Day	15 Day
T0	12±0.1	12.2±0.1	12.3±0.2
T1	12±0.1	12.3±0.2	12.5±0.3
T2	12±0.1	12.5±0.3	13.0±0.5
T3	12±0.1	12.4±0.4	12.8±0.4
T4	12±0.1	12.2±0.1	12.5±0.3
T5	12±0.1	11.9±0.1	11.8±0.1

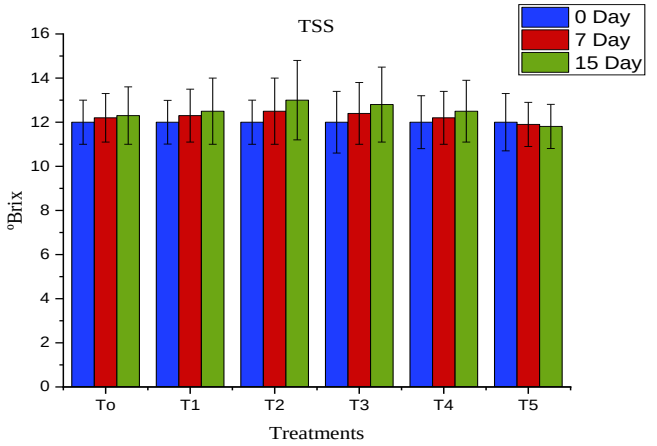

Figure 1. Effect of storage on TSS of mango juice at room temperature and 4℃. The bars in this graph represent mean values of three replicates and error bars represent standard deviation.

***pH of mango juice*:** This study examined the impact of various treatments on pH of mango juice stored at room temperature and 4 °C as shown in table 3. The study determined that decrease in pH was observed in all samples except T2 and T3. T2 (3.80±0.04-3.80±0.04) and T3 (3.85±0.05-3.85±0.04) shows effective result that maintain pH throughout the storage of 15 days at room temperature and 4 °C respectively.

***Acidity of mango juice*:** This study examined the impact of various treatments on acidity of mango juice stored at room temperature and 4 °C as shown in table 4. Maximum increase in acidity was observed in T5 (0.160±0.003-0.210±0.007-0.210±0.007) and T4 (0.150±0.002-0.185±0.005). Minor increase was observed in T1 (0.163±0.003-0.170±0.003) and to (0.150±0.002-0.180±0.005). While T2 (0.175±0.004-0.170±0.003) and T3 (0.165±0.003-0.163±0.004) shows stability in acidity at the end of storage for 15 days at room temperature and 4 ℃ respectively.

Table 3. Effect of storage on pH of mango juice at room temperature and 4℃.

Groups	pH		
	0 Day	07 Day	15 Day
T0	3.60±0.03	3.48±0.02	3.35±0.01
T1	3.90±0.06	3.70±0.03	3.58±0.02
T2	3.80±0.04	3.75±0.03	3.80±0.04
T3	3.85±0.05	3.70±0.02	3.85±0.04
T4	3.90±0.06	3.68±0.02	3.50±0.02
T5	3.80±0.04	3.59±0.03	3.10±0.01

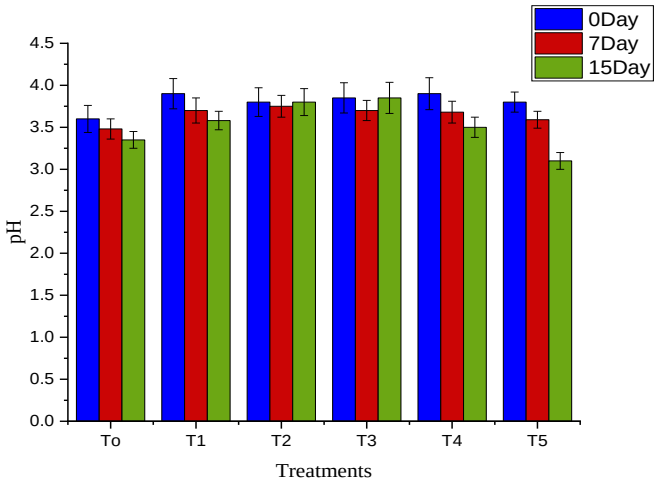

Figure 2. Effect of storage on pH of mango juice at room temperature and 4℃. The bars in this graph represent mean values of three replicates and error bars represent standard deviation.

Table 4. Effect of storage on acidity of mango juice at room temperature and 4℃.

Groups	Acidity		
	0 Day	07 Day	15 Day
T0	0.150±0.002	0.170±0.004	0.180±0.005
T1	0.163±0.003	0.155±0.002	0.170±0.003
T2	0.175±0.004	0.160±0.003	0.172±0.004
T3	0.165±0.003	0.160±0.003	0.163±0.004
T4	0.150±0.002	0.175±0.004	0.185±0.005
T5	0.160±0.003	0.195±0.006	0.210±0.007

***Ascorbic acid of mango juice*:** This study examined the impact of various treatments on ascorbic acid of mango juice stored at room temperature and 4 °C as shown in table 5. This study revealed that decrease in ascorbic acid was observed in all samples. Maximum decrease was observed in T5 (2.257±0.005- 0.865±0.003), T4 (2.255±0.005-0.995±0.004) and T1 (1.961±0.004-0.866±0.002). Minor decrease was noted in T0 (0.412±0.002-0.311±0.002). While ascorbic acid

was stable in T2 (1.572±0.003-1.521±0.001) and T3(1.546±0.003-1.508±0.005) at the end of storage for 15 days at room temperature and 4 ˚C respectively.

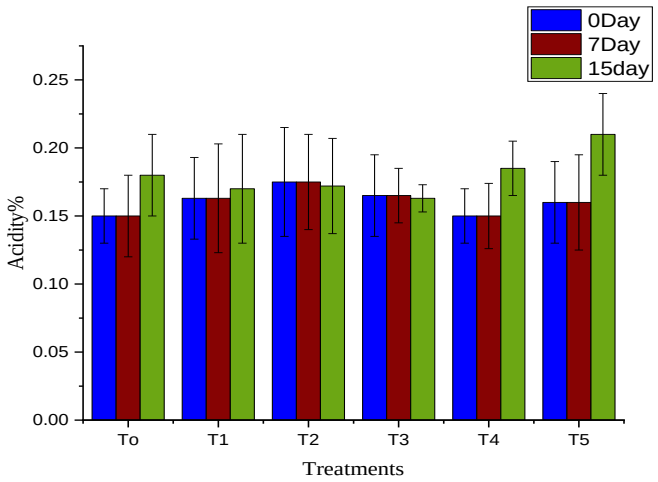

Figure 3. Effect of storage on acidity of mango juice at room temperature and 4℃. The bars in this graph represent mean values of three replicates and error bars represent standard deviation.

Table 5. Effect of storage on ascorbic acid of mango juice at room temperature and 4℃.

Groups	Ascorbic acid		
	0 Day	07 Day	15 Day
T0	0.412±0.002	0.380±0.001	0.311±0.002
T1	1.961±0.004	0.955±0.003	0.866±0.002
T2	1.572±0.003	1.561±0.002	1.521±0.001
T3	1.546±0.003	1.512±0.004	1.508±0.005
T4	2.255±0.005	1.686±0.003	0.995±0.004
T5	2.257±0.005	1.775±0.004	0.865±0.003

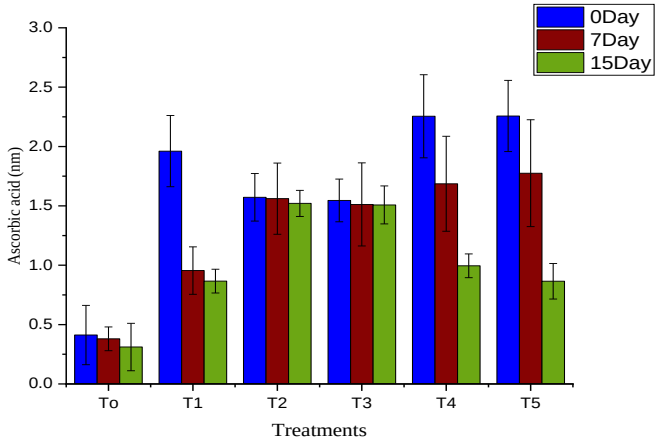

Figure 4. Effect of storage on ascorbic acid of mango juice at room temperature and 4℃. The bars in this graph represent mean values of three replicates and error bars represent standard deviation.

***Mangiferin of mango juice*:** This study examined the impact of various treatments on mangiferin of mango juice stored at room temperature and 4 ˚C as shown in table 6. Decreased in the concentration of mangiferin was observed in all samples. Maximum decrease was observed in T5 (1.372±0.004-0.776±0.003) and T1 (1.126±0.004-0.832±0.002). While minimum decrease was noted in T2 (1.338±0.005-1.125±0.003) and T3(1.213±0.004-1.051±0.002) at the end of storage of 15 days at room temperature and 4 ℃ respectively.

Table 6. Effect of storage on mangiferin of mango juice at room temperature and 4℃.

Groups	Mangiferin		
	0 Day	07 Day	15 Day
T0	0.515±0.003	0.400±0.002	0.311±0.001
T1	1.126±0.004	0.912±0.003	0.832±0.002
T2	1.338±0.005	1.176±0.004	1.125±0.003
T3	1.213±0.004	1.119±0.005	1.051±0.002
T4	1.084±0.003	1.055±0.004	0.800±0.004
T5	1.372±0.004	1.107±0.003	0.776±0.003

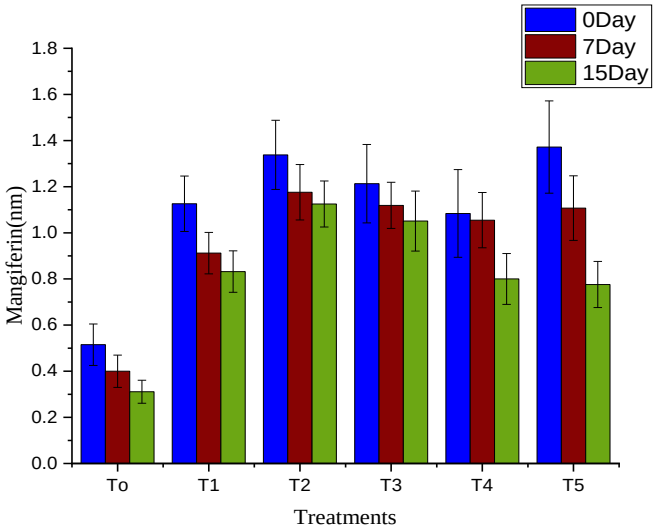

Figure 5. Effect of storage on mangiferin of mango juice at room temperature and 4℃. The bars in this graph represent mean values of three replicates and error bars represent standard deviation.

***Turbidity of mango juice*:** This study examined the impact of various treatments on turbidity of mango juice stored at room temperature and 4 ˚C as shown in table 7. Decrease in turbidity was noted in all samples. Maximum decrease was noted in T2 (0.626±0.004-0.300±0.002), T3 (0.570±0.004-0.370±0.001) and T1 (0.565±0.003-0.420±0.001). Minor decrease was noted in T0 (0.400±0.005-0.360±0.003) and T1 (0.565±0.003-0.420±0.001). Minor increase was observed in T5 (0.474±0.002-0.570±0.003).

Table 7. Effect of storage on turbidity of mango juice at room temperature and 4℃.

Groups	Mangiferin		
	0 Day	07 Day	15 Day
T0	0.400±0.005	0.391±0.004	0.360±0.003
T1	0.565±0.003	0.387±0.002	0.420±0.001
T2	0.626±0.004	0.465±0.003	0.300±0.002
T3	0.570±0.004	0.490±0.002	0.370±0.001
T4	0.559±0.003	0.608±0.003	0.476±0.002
T5	0.474±0.002	0.545±0.004	0.570±0.003

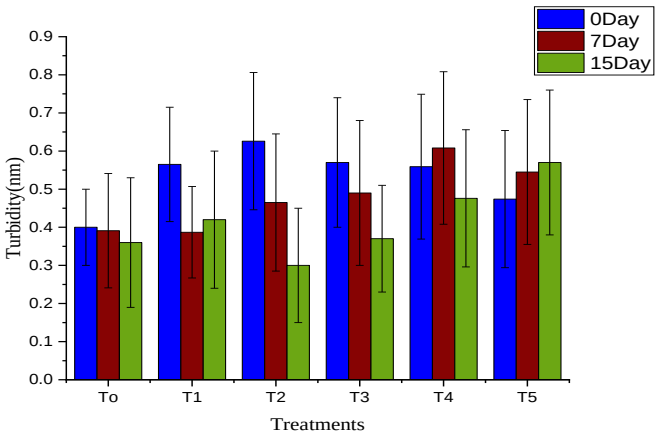

Figure 6. Effect of storage on turbidity of mango juice at room temperature and 4℃. The bars in this graph represent mean values of three replicates and error bars represent standard deviation.

***Sensory evaluation*:** Sensory evaluation plays an important role in determining the quality of food products. The sensory quality of stored mango juice was evaluated while various treatment and storage conditions. A panel of judges assessed taste, flavor, color, sweetness, thickness, mouthfeel, and overall acceptability.

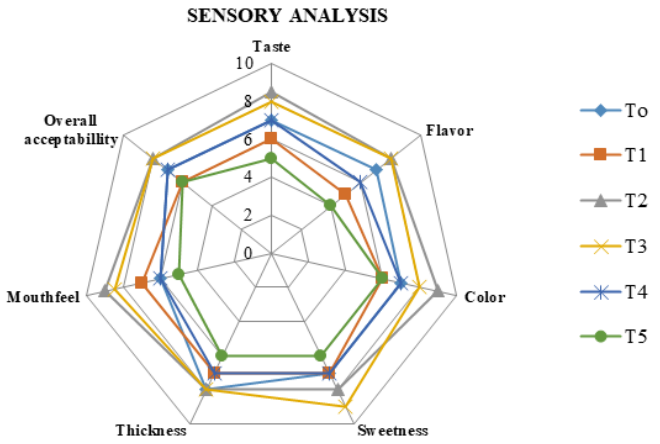

Figure 7. Sensory analysis of mango juice (Taste, Flavor, Color, Sweetness, Thickness, Mouthfeel, Overall acceptability).

The sensory evaluation was carried out as shown in Figure 7. The results obtained was observe that peppermint oil nanoemulsion had crucial impact on the sensory properties of mango juice during storage. The control groups (T0 and T1) which have not peppermint oil nanoemulsion contained lower sensory scores in comparison to groups containing nanoemulsion. Among the groups T2 and T3 have more effectiveness in preserving the taste, flavor, color, sweetness, thickness, mouthfeel and overall acceptability. Group T5 has lowest sensory score. T2 and T3 have highest sensory score as compared to other groups (T0, T1 and T4).

DISCUSSION

In this study, a nanoemulsion with diameter (<200 nm) was developed utilizing the extract derived from peppermint plants. This study aims to reduce the utilization of synthetic preservatives in the production of formulated fruit juice. The dosage of Sodium benzoate and Potassium metabisulphite was decreased, while the utilization of NE was found to be significant in the preservation of the fruit juice. The impact of various concentrations of peppermint oil nanoemulsion, Sodium benzoate, Potassium sorbate and Potassium metabisulphite in different combinations on TSS (%), pH, acidity, ascorbic acid, mangiferin and turbidity of mango juice stored at room temperature and 4 ˚C was examined. The findings indicated that T2 and T3 exhibited the highest level of overall acceptability. Furthermore, they were predominantly favoured due to their vibrant color and appealing taste. The storage stability of food can be extended through the use of natural compounds, which have the ability to hinder the growth of foodborne spoilage or pathogenic microbes and protect food from damage caused by oxidative stress (Teixeira *et al.*, 2012). The application of essential oils (EOs) in food preservation is therefore of considerable interest. El Moussaoui *et al.* (2016) observed a significant effect of *Origanum elongatum* essential oil, either alone or in conjunction with heat treatment, on both the microbiological and chemical characteristics of pomegranate juice during a storage period of 16 days at a temperature of 20 ℃.

The physicochemical properties of all samples were assessed. The findings of this study demonstrate that there was a noticeable elevation in TSS across all samples. The highest increase in TSS was observed in treatment groups T2 and T3. The observed substantial rise in TSS in samples may be attributed to enhanced moisture evaporation and fruit maturation through the degradation of polysaccharides. The range of TSS observed in the tested juice samples was 12-13˚Brix%. According to Hounhouigan (2014), a marginal elevation in TSS during the storage period is deemed acceptable as it contributes to the enhancement of product quality. The observed increase in TSS could potentially be attributed to the processes of solubilization or hydrolysis facilitated by acid, leading to the formation of sugars. Deka

and Sethi (2001) demonstrated a comparable outcome in mixed fruit juice, while Singh and Mathur (1953) observed a similar result in cashew apple juice. Similarly, Hussein *et al.* (2017) reported that the TSS of all beverage samples tested ranged from 13.7% to 17.1%. The aforementioned values conform to the established TSS standards for juice products, which typically fall within the range of 10-20 °Brix.

pH is another crucial factor in food preservation (Charfi *et al.,* 2019) . The acidity level of fruit juice is influenced by the degree of maturity and ripeness of the fruits utilized during the production process. The results of the physico-chemical analysis of all samples revealed a pH range. This falls within the standard range (2–5) for fruit and vegetable beverages (Tasnim *et al.,* 2010). Furthermore, it agrees with studies from Adubof uor *et al.* (2010) (4.82-4.99) and Ndife *et al.* (2013), (3.23-4.08) for various fruit juice brands. A stability in pH was observed in the samples from T2 and T3. Using plant-based nanoemulsion as a natural preservative in apple juice, Barman *et al.* (2022) also recorded a minor increase in pH. A slight elevation in pH levels can lead to the acid hydrolysis of polysaccharides, resulting in the formation of monosaccharides and disaccharides. This process contributes to an increase in sweetness and a decrease in sourness. The fluctuations in pH levels observed in fruit juice over the course of storage may be attributed to variations in storage temperature. Dhaka *et al.* (2016) also documented comparable findings. The observed rate of pH stability was found in both samples and T3. This suggests that the compound NE exhibited preservative properties.

Acidity is a prominent determinant of fruit flavour. The results obtained from T2 and T3 indicate that there is a consistent level of acidity observed at the end of the storage period. No abrupt chemical transformations were detected, suggesting the presence of stability without any signs of spoilage or degradation in quality. In contrast, Akhtar *et al.* (2010) observed an elevation in the acidity levels of chemically preserved mango pulp when utilizing sodium benzoate and potassium metabisulphite. Doreyyapa *et al.* (2001) also documented the findings regarding the rise in acidity and decline in pH observed during the storage of mango pulp. The reported rise in acidity can be attributed to the elevated concentration of weakly ionized acids and their corresponding salts that occur during the storage period. During the course of this study, it was observed that samples T2 and T3, which were treated with peppermint oil nanoemulsion, did not exhibit any alterations in acidity levels upon completion of the storage period. This observation suggests that the nanoemulsion effectively served as a preservative agent.

Ascorbic acid, commonly known as vitamin C, plays a crucial role as a vital nutrient found abundantly in various fruits and vegetables. The presence of ascorbic acid and mangiferin in mangoes is significant due to their potent antioxidant properties (Zapata Londoño *et al.,* 2019). This study aimed to investigate the variations in Ascorbic acid content across different storage conditions in all samples. Minimum decrease was observed in T2 and T3 samples. The findings of this study were consistent with the research conducted by Mkandawire *et al.,* (2016). The concentration of ascorbic acid, exhibited a decline over the course of storage in juice blends. This decrease can likely be attributed to the inherent sensitivity of ascorbic acid to environmental factors such as oxygen, light, and heat. The variation in vitamin C content was reliant upon the temperature and the inclusion or exclusion of a preservative. The observed increase in vitamin C losses at a temperature of 37 ºC compared to 4 ºC can likely be attributed to the inherent instability of vitamin C when exposed to elevated temperatures. The findings of this study are consistent with previous research that has shown a positive correlation between elevated temperature and longer storage duration with higher levels of vitamin C degradation (Mgaya-Kilima *et al.,* 2014; Falade *et al.,* 2004). In a study conducted by Ma *et al.* (2020), it was observed that the duration and temperature of storage had a notable impact on the ascorbic acid content of fresh watermelon juice. Particularly, the juice stored at 37°C exhibited a more pronounced decline in ascorbic acid content compared to those stored at 4 and 25°C and documented a decline in pH levels and vitamin C content during a one-month storage Period at both room temperature and refrigeration conditions for pawpaw, pineapple, and watermelon juices. The observed decline in vitamin C content in the juices over time may be attributed to the impact of oxidation reactions occurring during storage, which is influenced by the inherent instability of vitamin C (Okorie *et al.,* 2009). The refrigerated juices shown higher levels due to the enhanced stability of the juice at lower temperatures.

Mangiferin is a prominent constituent found in mango fruit (Zapata-Londoño *et al.,* 2020). This study observed a decrease in the concentration of mangiferin across all samples. While minimum decrease was noted in T2 and T3 samples. In a study, Zapata Londoo *et al.* (2019) found that mangiferin is more susceptible to degradation with time than total phenols and ascorbic acid in juice.

This study examined that concentration of turbidity decreased in all samples. Maximum decrease was noted in T2, T3 and T1 samples. Turbidity in the samples treated with HT reduced by 57.1% over the first 6 days of the 15 days' storage period and then stayed the same after that until the 15 days. However, the turbidity in the samples treated with HPP-500 and HPP-600 decreased by 27% and 22.4%, respectively. Turbidity in a vegetable smoothie containing apple, carrot, zucchini, pumpkin, and leek treated at 85 ºC /7 minutes and HPP (350 MPa/5 min/10 ºC) decreased by 90% and 38%, respectively, after 28 days at 4 ºC. Pectin degradation caused by pectinmethylesterase has been implicated in a reduction of turbidity in smoothies and juices (Sila *et al.,* 2009).

In this study T0 and T1 (control group) have lower sensory scores in comparison to T2 and T3 which have peppermint oil nanoemulsion. Among all T2 and T3 demonstrated the most successful at maintaining the taste, flavor, color, sweetness, thickness, mouthfeel, and overall acceptability of mango juice as evidenced by the markedly higher scores assigned. T2 and T3 contributed to improve the sensory qualities of the mango juice as compared to T0 and T1 (control groups). On day 15 taste, flavor, color, sweetness, thickness, mouthfeel, and overall acceptability scores were noticeably higher in T2 and T3 in comparison with T0, T1, T4 taste, flavor, color, sweetness, thickness, mouthfeel, and overall acceptability. T5 has lowest sensory scores because it lost sensory qualities taste, flavor, sweetness, mouthfeel and overall acceptability stored at room temperature for15 days. The main score of judges for taste, flavor, color, sweetness, thickness, mouthfeel, and overall acceptability of mango juice was maximum in sample T6, while minimum mean score was recorded in sample T1. Maximum decrease was observed in sample T1 while minimum decrease was recorded in sample T5 Sanini *et al*. (2000).

***Conclusion*:** The results concluded that peppermint oil nanoemulsion has a significant potential as natural preservative along with antioxidant. The results also indicated that the use of peppermint oil nanoemulsions decreased the use of synthetic preservatives e.g.: sodium benzoate and potassium metabisulfate.

***Authors' contributions*:** All the authors in this paper contributed equally.

***Conflict of interest*:** The authors declare no conflict of interest.

***Funding*:** No external funding was involved.

***Ethical statement*:** N/A.

***Availability of data and material*:** All data is published in this article.

***Consent for publication*:** All authors submitted consent to publish this research article in JFPNR.

***SDGs addressed*:** Zero Hunger, Good Health and Well-being and Industry, Innovation, and Infrastructure.

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